

(19)



Europäisches Patentamt  
European Patent Office  
Office européen des brevets



(11)

**EP 1 138 341 A2**

(12)

**EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
04.10.2001 Bulletin 2001/40

(51) Int Cl.7: **A61M 16/10, A61M 16/16**

(21) Application number: **01106827.7**

(22) Date of filing: **19.03.2001**

(84) Designated Contracting States:  
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE TR**  
Designated Extension States:  
**AL LT LV MK RO SI**

(72) Inventors:  
• **Seakins, Paul John**  
• **Pakuranga, Auckland (NZ)**  
• **Smith, Malcolm David**  
• **Royal Oak, Auckland (NZ)**  
• **Thudor, Mohammad**  
• **Parnell, Auckland (NZ)**

(30) Priority: **21.03.2000 NZ 50349500**

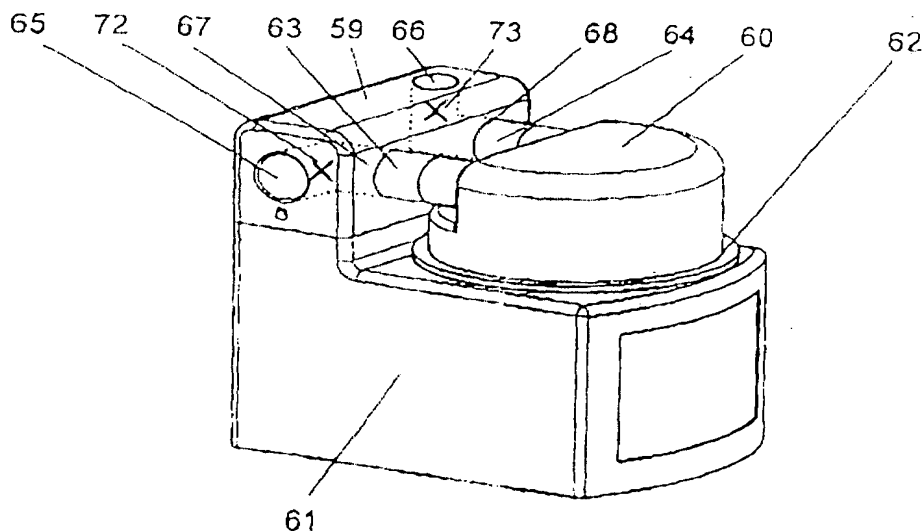
(71) Applicant: **FISHER & PAYKEL LIMITED**  
**Auckland (NZ)**

(74) Representative: **Brown, John David**  
**FORRESTER & BOEHMERT**  
**Pettenkoferstrasse 20-22**  
**80336 München (DE)**

**(54) Humidification apparatus**

(57) A humidifier and humidity sensor is disclosed for use with a breathing assistance apparatus. The humidity sensor preferably includes means to sense absolute humidity, relative humidity and/or temperature at both the patient end and humidifier end. The humidifier

may also include provision to both control independently the humidity and temperature of the gases. Further, a chamber manifold is disclosed to facilitate easy connection of the humidifier to various outlets, inlets and sensors. A heated conduit is described which provides a more effective temperature profile along its length.



**Figure 12**

**EP 1 138 341 A2**

## Description

### FIELD OF THE INVENTION

[0001] The present invention relates to the use of an humidification system particularly, but not solely, for providing respiratory assistance to patients receiving mechanical ventilation or respiratory support.

### DESCRIPTION OF THE PRIOR ART

[0002] A number of methods are known in the art for supplying humidified gases to a patient requiring breathing assistance. Such prior art humidifiers generally comprise a source of pressurised air (or other mixture of gases), a humidification chamber including a source of water and a heating means to vaporise the water, and a conduit to convey the humidified gases to the patient or user.

[0003] For example US patent 4,038,980 describes a "flash vaporisation" humidifier where water drips onto a low thermal mass heater to create respiratory humidity. It mentions "control means may be provided automatically to regulate the water supply rate in response to means sensing the relative humidity", however they prefer a manual control of water flow rate. Thus it incorporates a humidity sensor and controls the water rate, as opposed to controlling the amount of electrical heating.

[0004] US patent 5,092,326 also describes the use of a humidity sensor in a humidifier. It describes a high frequency ventilation system that incorporates a heated humidifier and a humidity sensor, where these are linked to a central microprocessor. Apparatus is disclosed to moisten a gas mixture supplied to the airway, and a microprocessor controls the amount of moisture supplied to the gas mixture. While it discloses a humidity sensor at the patient airway, it doesn't describe the actual humidification configuration to be used.

[0005] US patent 5,769,071 describes a humidifier incorporating a heat and moisture exchanger (HME), supply of water to the HME, heater element and humidity sensor. The humidity sensor can control humidity via water supply rate or temperature (via the heater element). Also the humidity sensor is described as being at the patient airway.

[0006] US patent 5,988,164 describes a heated breathing tube system for use with a humidifier. This uses a relative humidity sensor (located near the patient) to control the amount of heating provided by the heated breathing circuit so that the gas is at a constant level of relative humidity. The heated breathing circuit may use either electrical heating, or heating via warm recirculating water in a tube. Also described is a method of control of the electric heater wire or heated water tube based on the output of relative humidity sensor.

[0007] The previously mentioned US patents 4,038,980 and 5,769,071 both describe humidifiers where the humidification chamber is located close

(proximal) to the patient. These have the disadvantage of introducing weight, heat and complexity near the patient which is inconvenient and could be painful to the patient. Of the cited prior art only US patent 5,988,164 specifically describes the humidification chamber as being located remotely from the patient.

[0008] There are several disadvantages of the prior art systems using a humidification chamber located remotely from the patient. It is normally assumed that gases leaving such prior art humidifiers are saturated with water vapour (100% relative humidity). However there is no guarantee that the gases leaving such humidifiers are in fact saturated with water vapour. In certain circumstances (e.g. with the incoming air already warm), the gases leaving such humidifiers can be significantly less than 100% relative humidity. This is because as they are typically controlled to achieve a desired outlet gas temperature, which in such cases may not be much more than the incoming air.

[0009] Another drawback of the prior art systems is that condensation can occur in the (sometimes heated) conduits connecting the patient to the respiratory assistance equipment. This may occur if the temperature profile along such conduits is not even and allows some parts of the conduit to be colder than the gas at these points.

[0010] A third disadvantage of such prior art systems is where the gas leaving the humidifier is at 100% relative humidity it must be heated immediately by some form of conduit heater or it may lose heat through the walls of the conduit, which results in condensation and therefore a drop in the amount of absolute humidity contained in the gas.

[0011] Another fourth disadvantage of the prior art systems is the need for a sensor very near to the patient, which adds to the weight and bulk of equipment at the patient's airway.

[0012] A fifth disadvantage of the prior art systems is that intermittent or varying flow rates will cause the absolute humidity that is generated by the humidifier to be uneven. This is because the flow rate is varying faster than any control loop that might operate in such humidifiers. Air which passes through the humidifier at a high flow rate has had little time to be heated and humidified, while air that passes through the chamber at a low flow rate will be hotter and contain higher absolute humidity. Consequently it is difficult for a conduit in such prior art systems to transport these high humidity boluses without condensation and consequent loss of absolute humidity.

### SUMMARY OF THE INVENTION

[0013] It is therefore an object of the present invention to provide a humidification system which goes some way to overcoming the above mentioned disadvantages, or which will at least provide the public with a useful choice.

**[0014]** Accordingly in a first aspect the present invention consists in a humidification apparatus for humidifying a gases flow to be supplied to a patient or other person in need of such gases comprising:

humidification chamber means and having an inlet and an outlet to allow said gases flow to pass through said humidification chamber means, chamber heating means provided adjacent said humidification chamber means and adapted to vaporise liquid water in said humidification chamber means in order to provide water vapour to said gases flow passing through said humidification chamber means, gases transportation pathway means connected to said outlet of said humidification chamber means to convey said gases flow to said patient or other person in need of such gases,

***characterised in that***

humidity sensing means configured to provide an indication of the absolute humidity of said gases flow at least at one point in the flow path through said apparatus of said gases flow.

**[0015]** In a second aspect the present invention consists in a humidification apparatus for humidifying a gases flow to be supplied to a patient or other person in need of such gases comprising:

humidification chamber means and having an inlet and an outlet to allow said gases flow to pass through said humidification chamber means,

***characterised in that***

chamber heating means provided adjacent said humidification chamber means including wet heating means adapted to vaporise liquid water in said humidification chamber means in order to provide water vapour to said gases flow passing through said humidification chamber means and dry heating means adapted to directly heat said gases flow passing through said humidification chamber means, gases transportation pathway means connected to said outlet of said humidification chamber means to convey said gases flow to said patient or other person in need of such gases, and control means configured to energise said wet heating means and said dry heating means to achieve a desired level of absolute humidity.

**[0016]** In a third aspect the present invention consists in a humidification apparatus for humidifying a gases flow to be supplied to a patient or other person in need of such gases comprising:

humidification chamber means and having an inlet and an outlet to allow said gases flow to pass through said humidification chamber means,

chamber heating means provided adjacent said humidification chamber means and adapted to vaporise liquid water in said humidification chamber means in order to provide water vapour to said gases flow passing through said humidification chamber means,

gases transportation pathway means connected to said outlet of said humidification chamber means to convey said gases flow to said patient or other person in need of such gases, and

***characterised in that***

regulated conduit heating means are associated with said gases transportation means and configured to regulate the temperature profile of said gases flow along said gases transportation pathway means and/or of said gases transportation pathway means, to substantially coincide with a predetermined profile.

**[0017]** In a forth aspect the present invention consists in a humidification apparatus for humidifying a gases flow to be supplied to a patient or other person in need of such gases comprising:

humidification chamber means and having an inlet and an outlet to allow said gases flow to pass through said humidification chamber means, chamber heating means provided adjacent said humidification chamber means and adapted to vaporise liquid water in said humidification chamber means in order to provide water vapour to said gases flow passing through said humidification chamber means, and

***characterised in that***

chamber manifold means including mounting means in use housing at least one sensing means in proximity to said outlet of said humidification chamber means said chamber manifold means configured to connect:

said inlet of said humidification chamber means to a supply conduit means said supply conduit means in use in fluid communication with a gases supply means for supplying said gases flow at a desired pressure, and/or said outlet of said humidification chamber means to a gases transportation pathway means for conveying said gases flow to said patient or other person in need of such gases.

**[0018]** To those skilled in the art to which the invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the scope of the invention as defined in the appended claims. The disclosures and the descriptions herein are purely illustrative and are not intended to be in any sense limiting.

**[0019]** The invention consists in the foregoing and al-

so envisages constructions of which the following gives examples.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0020] One preferred form of the present invention will now be described with reference to the accompanying drawings in which;

Figure 1 shows an example of an humidification system, comprised of three parts,  
 Figure 2 shows a chamber which incorporates a metal element,  
 Figure 3 shows a chamber using a porous material to provide a heating and humidifying function,  
 Figure 4 shows a chamber using a semipermeable membrane,  
 Figure 5 shows a chamber with a variable valve to adjust the ratio of gas which are bypassed,  
 Figure 6 shows a chamber with an adjustable valve 30 where one part of the gas gets humidified while the other is heated,  
 Figure 7 shows a chamber where the dry gas entering chamber is pre-heated,  
 Figure 8 shows a chamber where the dry gas entering chamber is heated after leaving the chamber,  
 Figure 9 shows a chamber combined with an unheated, well insulated delivery tube,  
 Figure 10 shows construction of a tube incorporating flexible PTC elements in a parallel wire configuration,  
 Figure 11 shows a humidifier configuration using the tube in Figure 10, and  
 Figure 12 shows a chamber manifold.

## DETAILED DESCRIPTION OF THE INVENTION

[0021] Figure 1 illustrates a typical respiratory humidification system, comprised of three parts:

- 1) a humidification chamber located at a distance from the patient, which heats and substantially saturates gases flowing through it;
- 2) a delivery system consisting of a flexible tube which carries humidified gases from the humidification chamber 1 to the gas outlet 5; and
- 3) a heater base which heats the humidification chamber 1 and provides measurement and control functions.

[0022] The gas to be humidified flows into the chamber 1 from port 4 and leaves the delivery system 2 at gas exit port 5. Gas from exit port 5 flows to a patient via a face mask or similar (not shown). The system is controlled using sensors located at positions 7 and 8 - typically temperature probes. Dry gases at the gas input 4 are heated and humidified by passing over the surface of hot water 6 in the chamber 1 so that they are substan-

tially saturated with water vapour when they leave chamber 1 at exit port 10. Hot water 6 is heated by heater plate 9 and the amount of heating is controlled so that the gas reaches a predetermined temperature at exit port 10. This temperature is measured by sensor 7. Therefore the humidification chamber 1 acts to heat and humidify the medical gases so that they are substantially saturated at the output of chamber 1, and arc at a predetermined temperature.

[0023] The gas delivery system 2 (also known as a delivery tube or breathing circuit) consists of a flexible tube 11 containing a heater 12, which may consist of a heated resistance wire. The gas from the humidification chamber 1 passes through the tube 11 and is heated by heater 12 to offset heat losses through the walls of tube 11. The amount of heating applied to heater 12 is regulated so that the gas reaches a predetermined temperature at gas outlet 5, as measured by sensor 8. The control temperature at sensor 8 is usually higher than the control temperature at sensor 7, so that the gas is heated along tube 11 to ensure that condensation doesn't occur in the tube.

[0024] The system as described has gas entering gas inlet 4 from a continuous flow gas source (not shown) and exiting the system through gas outlet 5. However the system is equally applicable where the gas source is a ventilator, which creates intermittent flow patterns to provide breaths to a patient. In this case gas outlet port 5 is connected directly to gas inlet port 16. The patient is connected to port 17 via an endotracheal tube or similar (not shown). During patient inspiration dry gases from the ventilator enter the system at inlet port 4, pass through chamber 1, delivery system 2, pass through wye-piece 13 and reach the patient through port 17. During patient exhalation gases pass back through port 17, through wye-piece 13, tube 14 and leave through gas outlet port 18. Tube 14 may also be heated by heater 15 to prevent condensation.

## 40 Absolute humidity sensing

[0025] Humidifiers incorporating humidity sensors for display or control have been described in the prior art, however all used humidity sensors which were positioned at the patient airway. The current work describes novel humidifier configurations incorporating a humidity generating chamber located at a position which is remote from the patient, a heated breathing circuit to transfer humidity to the patient, and humidity sensors to control the level of absolute or relative humidity supplied to the patient. These humidity sensors are to be located either:

- 1) at the chamber outlet only,
- 2) at both the chamber outlet and near the patient, or
- 3) near the patient only.

**[0026]** One aspect of the present invention would be to use a humidity sensor as sensor 7. The purpose of humidity sensor 7 is to determine the absolute amount of humidity which is being generated by chamber 1. Accordingly an absolute humidity sensor would be ideal for use as sensor 7, although the use of a relative humidity sensor with associated temperature sensor could equally be used. This system has the advantage of creating a controlled level of absolute humidity at chamber outlet 10, however this level of absolute humidity may not reach the patient if condensation is allowed to occur in tube 11.

**[0027]** An alternative system which would overcome this disadvantage is to use a second absolute humidity sensor at point 8 instead of a temperature sensor. The difference in absolute humidity between sensors 7 and 8 allows the humidifier to determine whether condensation is occurring between the two points. If the two absolute humidity sensors 7 and 8 read the same level of absolute humidity then no condensation is occurring in the tube. If the absolute humidity at sensor 7 is greater than at sensor 8, then the difference shows the rate of condensation that is occurring.

**[0028]** One control strategy would be to control the amount of heating provided to heater 12 so that the absolute humidity difference is reduced to zero. However the tube may still contain mobile condensate because the humidity difference only describes the rate of condensation, not the absolute amount of condensate in the tube. Another control strategy is to remove this condensate and hence create a dry tube by heating heater 12 so that the rate of measured condensation is negative (i.e. condensation is being evaporated in tube 11) until the measured condensation rate reaches zero, indicating that all of the condensate has been removed. The amount of heating can then be reduced until the sensors show that condensation has just started to occur, then the heating can be increased slightly to the optimum level. Drying out of the tube may be a continuous process, or may be initiated at regular time intervals.

**[0029]** Another variation of the system shown in Figure 1 would be to use a temperature sensor for sensor 7 and an absolute humidity sensor at point 8. This system is simpler than having an absolute humidity at both points 7 and 8. In operation the controller would have to adjust the amount of heating at heater 12 and heater plate 9 so that the correct level of absolute humidity was reached without condensate in delivery tube 12. In practice two separate control algorithms would be required, one to control the amount of heating occurring in tube 11 so that no condensation occurred, and another to control heater plate 9 so that the desired level of absolute humidity was generated in chamber 1. The two algorithms could work concurrently because the heater plate 9 will respond slower than heater 12, so quick changes in absolute humidity would indicate the action of heater 12. Sensor 7 provides a control point for heater plate 9, but may not be needed.

### Low relative humidity chambers

**[0030]** All systems described so far have used a chamber 1 which attempts to humidify the gas leaving gas outlet 10 to a high level of relative humidity. While this condition isn't essential for the correct operation of the new humidification configurations just described because they use humidity control, it was essential for the prior art humidifier where control is purely based on temperature. However there are some advantages to be gained from using a chamber which heats gases to the correct absolute humidity, but at a low relative humidity (i.e. the temperature of the gas is higher than the dew-point of the gas, therefore the gas is not saturated).

**[0031]** The first advantage is that it is easier to design a heated delivery system to transport such a gas without condensation, since the gas doesn't need to be heated immediately after it enters the delivery tube to prevent condensation. Secondly, the use of low relative humidity gases leaving the chamber means that the heater element 12 can be rated at a lower power than would otherwise be the case, as the gas already has a higher energy content and can tolerate a greater loss of energy before the gas condenses in the tube 12. It may even be possible to use an unheated, well insulated breathing circuit instead of a heated breathing circuit if the chamber provides gas with enough energy. Note that low relative humidity chambers can only be used if the heating to the chamber is controlled using an absolute humidity sensor, not a temperature sensor, since otherwise the absolute humidity output would be too low.

**[0032]** To this end, some humidification chamber configurations which provide a high temperature, low relative humidity gas output are shown in Figures 2 - 8. Figure 2 shows a chamber which incorporates a metal element 20 (e.g. a spiral scroll shape), but without wicking paper attached. This provides both dry heating (via the metal element) and heated humidification from the heated water 21. With this configuration the chamber 19 provides gas which is not saturated because some of the heating provided to the gas is dry heating via the metal scroll. The relative humidity generated by the chamber is affected by the gas flow path, scroll shape, dimensions, and the water level, and so is not readily adjustable in use. However chamber 19 does give the condensate reducing advantages provided by a low relative humidity, controlled absolute humidity output.

**[0033]** Figures 3 and 4 are alternative humidification chambers which provide low relative humidity, high temperature gases at their output. Figure 3 shows a chamber using a porous material 22 (such as a porous ceramic) containing water 23 to provide a heating and humidifying function, while Figure 4 shows a chamber using a semipermeable membrane 24 to provide a barrier to the water 25 in the chamber. In both cases these chambers provide dry heating via the porous or semipermeable material, as well as heated humidification from the water. In both cases the ratio of heating to hu-

midifying is fixed and cannot be easily adjusted except by limiting the water supply.

[0034] Figures 5 to 8 show chambers that can supply gases at varying levels of relative humidity and temperature. In Figure 5 a variable valve 26 allows us to adjust the ratio of gas which passes through the dry bypass tube 27 to that which flows across the surface of the water 28. The bypass tube passes under the water to heat the gas. The two gas streams merge at the output 29. This is an example of a "parallel" system where the gas splits and takes two different paths to provide heating and humidification. In Figure 6 the gas is again split into two gas paths using an adjustable valve 30. One part of the gas gets humidified by passing across the water 31 in chamber 32, while the other is heated by heater 58, which surrounds tube 33. The gas paths merge at junction 34.

[0035] The angle of variable valves 26 and 30 in Figures 5 and 6 may be permanently set, may be manually adjustable, or may be automatically adjustable. One advantage of an automatically adjustable valve would be to provide a constant level of humidity out of the chamber when used with intermittent flow rates, for example when used with a ventilator. These flow patterns can be a problem because parts of the breath cycle contain less humidity than other parts, due to the chamber providing less humidity at higher flow rates. One way to overcome this problem is to measure the instantaneous flow rate using a fast response flow sensor, and then rapidly adjusting the angle of the variable valve. A more practical method of achieving this effect would be to spring-load valves 26 and 30 using springs 70 and 71. This would mean that low flow rates would mostly pass through the bypass tubes, while high flow rates would operate the spring-loaded valve and allow more gas to pass across the water in the humidification chamber. The angle of the spring-loaded variable valve could also be used by the humidifier to measure the gas flow rate.

[0036] Figures 7 and 8 show alternative series configurations for low relative humidity chambers, where the dry gas entering chamber 35 containing heated water 36 is either pre-heated via heater 37 in Figure 7, or heated via heater 38 in Figure 8 after leaving the chamber. In both cases the heater provides dry heating to the gas and results in a low relative humidity, high temperature gas leaving outlet 39.

[0037] Any of the low relative humidity, high temperature chambers shown in Figures 2 to 8 can be used in conjunction with the humidity control schemes described previously in this patent, but not successfully with the prior art humidifier due to it being temperature controlled, not humidity controlled.

#### Insulated delivery tube

[0038] Another facet of the invention is shown in Figure 9. Here the low relative humidity, high temperature humidification system from Figure 8 has been combined

with an unheated, well insulated delivery tube. The incoming gas enters at port 35 into the standard humidification chamber 36 containing water 37 which is heated by heater plate 38. The gas is substantially saturated in the chamber then leaves the chamber through gas outlet 39 and enters heated tube section 40 which heats the humid gas to a higher temperature, so that it has a low relative humidity. The gas then passes through tube 41 which has an insulating layer 42 around it. Preferably the insulating layer is a thin jacket of stagnant air which reduces heat loss. As the high temperature gas, low relative humidity gas passes through the insulating tube, a small amount of heat is lost through the tube walls, and therefore the gas cools. However the amount of heating applied to heater 40 is controlled, so that the gas is never allowed to cool below its dewpoint, which would result in condensation within tube 41.

[0039] Several different sensor configurations are proposed. Firstly, sensor 43 could be an absolute humidity sensor which controls heater plate 38 so that chamber 36 produces the desired level of humidity. In one embodiment sensor 45 is a temperature sensor, which controls heater 40 so that the gas passing sensor 45 remains at a certain desired temperature. If this temperature is greater than the dewpoint of the gas at sensor 43, then condensation should not occur in tube 41. However there may already be condensate in tube 41 when the humidifier is turned on. If a humidity sensor is used for sensor 45 instead of a temperature sensor, then the level of condensate occurring in the tube 41 can be controlled. The algorithms described earlier in this patent for dual-humidity sensor control can be used with this system.

[0040] An alternative location for the absolute humidity sensor is at position 44 instead of 43. The absolute humidity here should be the same as at 43 because the gas has been heated and so hasn't lost any moisture. However there may be advantages to placing the absolute humidity sensor at 44, for instance due to better sensor operation in a low relative humidity environment. This location for the absolute humidity sensor can be used with either a temperature or absolute humidity sensor at location 45.

#### Humidifier configurations without any patient airway sensors

[0041] Yet another aspect of this patent relates to removing the need for a sensor at the patient airway. To remove this sensor safely, we must be certain that the gas entering the delivery tube has a safe level of temperature and absolute humidity, and that the surfaces inside the delivery tube do not exceed safe temperature levels. This implies a delivery tube that has a constant internal wall temperature,

[0042] It would be desirable, therefore, to have a heated delivery tube which self-regulates its temperature at a desired level. The heater could either be embedded

in the wall of the delivery tube itself, or it could lie inside the lumen of the delivery tube, or it could be wrapped around the outside of the delivery tube. Such a heater could be made from positive temperature coefficient (PTC) material (such as "Winterguard" from Raychem Corp., Menlo Park, California USA), so that the resistance of the heater increases if the heater is hot, resulting in reduced power. However the delivery tube may pass through more than one environment, or may have localised drafts present on certain parts of the tube. If the PTC elements are arranged in parallel, then the full benefit of the PTC heater can be envisaged. If the PTC elements are arranged in parallel, then the cold portions of the tube will have a lower resistance, which will result in more heat being dissipated. Thus the tube will tend to regulate its own temperature.

[0043] Figure 10 shows construction of a tube incorporating flexible PTC elements in a parallel wire configuration. The tube 48 is made of a flexible PTC material, which has two low resistive strip connections, 46 and 47, on either side of it. This allows each portion of the tube to consist of short conducting segments of tube connected in parallel between conductors 46 and 47. These segments are represented by dotted lines encircling the tube in Figure 10. The conductors 46 and 47 are connected to adjustable voltage source 49, which may be AC or DC. The tube would have an outer layer (not shown) which provides electrical insulation and thermal insulation to the tube. Each longitudinal segment of the tube will be able to regulate its own temperature independently of the rest of the tube. To enhance this operation, it may be necessary to provide parallel slots 50 running perpendicular to the axis of the tube, to eliminate electrical cross-connection between the different PTC segments.

[0044] Although one specific PTC heated tube design has been envisaged and described, other PTC tube designs could be used. It may also be of advantage to create a PTC tube that has a differing temperature profile along its length rather than a constant temperature profile. The PTC design could also be extended to incorporate PTC heaters in other parts of the patient breathing circuit, such as the flexible extension tube which is usually connected between the Y-piece (port 17 of Figure 1) and the patient's endotracheal tube. A further extension of the PTC tube concept would be into a self-heated and temperature controlled endotracheal tube.

[0045] The PTC tube described in Figure 10 allows us to create a humidifier which doesn't use any sensor at the patient airway. Figure 11 shows a humidifier configuration using this tube. Gas enters humidification chamber 52 via inlet port 51 and is humidified by water 53, heated by heater plate 54. Absolute humidity sensor 55 controls the heater plate so that the gas passing sensor 55 is at a desired level of absolute humidity. PTC tube 56 is heated by an external voltage (not shown) so that the internal surface temperature is at a constant desired temperature, which is selected to be above the dewpoint

of the gas. The gas which leaves tube 56 at outlet 57 will therefore be near the temperature of the tube, and containing the desired level of absolute humidity which was controlled by absolute humidity sensor 55.

[0046] A variation of the system shown in Figure 11 would be to use a temperature sensor at position 55. Another variation of a tube with a constant internal wall temperature would be a delivery tube with heated water or other fluid pumped through smaller conduits in the wall of the delivery tube. Since the heated fluid has a high specific heat relative to air, the temperature of the fluid remains fairly constant during passage through the delivery wall conduits.

#### 15 Use of a sensor / heater manifold

[0047] Traditional humidifiers have tended to use sensors that are probe shaped, so that they can be inserted through specifically designed holes in the side of the breathing circuit to measure temperature. However the humidifier configurations that have been described in this patent incorporate many sensors around the chamber, so the use of a manifold 59 as shown in Figure 12 may be useful.

[0048] The humidification chamber 60 is a removable item which can be slid onto the humidifier base 61 as shown in Figure 12. As the chamber 60 is slid onto the humidifier base 61, its base makes contact with heater plate 62 and its inlet and outlet ports 63 and 64 make contact with holes 67 and 68 inside the manifold 59. Dry air to be humidified enters the manifold at port 65, passes out of the manifold through port 67, and flows through port 63 into the chamber 60, where it is humidified.

[0049] After leaving chamber 60 the humid gas passes through chamber port 64 into manifold port 68. Finally the humid gas leaves manifold 59 through port 66 and passes to the breathing circuit.

[0050] The manifold may be a separate, removable assembly, or it may be an integral part of the humidifier base. It may contain temperature sensors, humidity sensors, flow sensors, or a heater element. These would be located inside the manifold 59 at positions 72 and 73. The manifold 59 may be heated to prevent condensation of humid gas. It could connect to both chamber ports 63 and 64 as described, or it may only connect to the outlet port 64. One advantage of using a manifold is that many sensors or heaters can be combined in a single, cleanable assembly, rather than requiring separate probes which need to be plugged into the breathing circuit. This simplifies connection and setup for the user. Another advantage of a manifold is that the incoming dry gas temperature and flow rate can easily be measured without additional probes and connections.

#### 55 Variations on the described configurations

[0051] Although absolute humidity sensors have been described with all of the different humidification

schemes described in this patent, relative humidity sensors could also be used. This may involve slightly different control algorithms to the ones described in this patent. Alternatively, a relative humidity sensor could be combined with a temperature sensor. This allows the absolute humidity to be calculated from relative humidity and temperature, rather than being measured directly.

[0052] All of the novel humidification schemes that have been described in this patent could be used with additional temperature sensors. These may provide additional benefits such as providing a safety backup in the event of a failed humidity sensor. Another benefit would be maintaining the temperature being delivered to the patient within certain limits so that the relative humidity is not too low, even though the absolute humidity was acceptable.

[0053] Similarly it may be useful to measure the air flowrate through the humidifier, as this is an important parameter which affects humidifier control. Therefore flow sensors could be incorporated within any of the previously described systems. One useful prior art flow sensor construction would be to use a sensor based on heat loss from a hot element in the airstream. If a heated humidity sensor is used, the amount of heating that is required for the sensor to achieve temperature can be used to determine the gas flow rate.

[0054] Infection control is a prime consideration when designing medical components. To prevent bacterial colonisation of the components in the humidification system, any parts which come in contact with the gas stream could be made out of antibacterial plastic. To prevent contamination of sensor probes, the probe ports could incorporate a disposable sheath which protects the probe from pathogens in the breathing circuit. This would be particularly applicable to temperature probes. In general humidity probes need to have contact with the gas stream so a disposable sheath would be inapplicable to humidity sensors, unless they worked on optical principles, or unless the sheath was made of water vapour permeable material, which did not allow the passage of pathogens. The protective sheath could be an integral part of a disposable breathing circuit.

[0055] The features disclosed in the foregoing description, in the following claims, and/or the accompanying drawings may, both separately and in any combination thereof, be material for realising the invention in diverse forms thereof.

## Claims

1. A humidification apparatus for humidifying a gases flow to be supplied to a patient or other person in need of such gases comprising:

humidification chamber means (1) and having an inlet (4) and an outlet (10) to allow said gases flow to pass through said humidification

chamber means (1),  
chamber heating means (9) provided adjacent said humidification chamber means (1) and adapted to vaporise liquid water (6) in said humidification chamber means (1) in order to provide water vapour to said gases flow passing through said humidification chamber means (1),  
gases transportation pathway means (11) connected to said outlet (10) of said humidification chamber means (1) to convey said gases flow to said patient or other person in need of such gases,

## characterised in that

humidity sensing means (7, 8) configured to provide an indication of the absolute humidity of said gases flow at least at one point in the flow path through said apparatus of said gases flow.

2. A humidification apparatus as claimed in claim 1 further comprising control means which receives as inputs the output from said humidity sensing means (7, 8) and said control means configured to estimate the rate of condensation of the vapour from said gases in said gases transportation pathway means (11).
3. A humidification apparatus as claimed in claim 2 wherein said humidity sensing means including a first absolute humidity sensor (7) in substantial proximity to said outlet (10) of said humidification chamber means (1).
4. A humidification apparatus as claimed in claim 3 wherein said gases transportation pathway means (11) having a patient end (5), distal to said end connected to said outlet (10) of said humidification chamber means (1), and said humidity sensing means further comprising a second absolute humidity sensor (8) in substantial proximity to said patient end (5) of said gases transportation pathway means (2).
5. A humidification apparatus as claimed in claim 4 wherein said estimate of the rate of condensation is based on the difference between the absolute humidity at said outlet (10) of said humidification chamber means (1), as indicated by the output of said first absolute humidity sensor (7), and the absolute humidity at said patient end (5) of said gases transportation pathway means (11), as indicated by the output of said second absolute humidity sensor (8).
6. A humidification apparatus as claimed in any one of claims 1 to 5 further comprising conduit heating means (12) adapted to heat said gases flow in said



gases transportation pathway means (11) and/or said gases transportation pathway means (11), and said control means configured to energise said conduit heating means (12) depending on at least said estimate of the rate of condensation, in order to minimise any condensation of the vapour from said gases in said gases transportation pathway means (11).

7. A humidification apparatus as claimed in any one of claims 1 to 5 further comprising conduit heating means (12) adapted to heat said gases flow in said gases transportation pathway means (11) and/or said gases transportation pathway means (11), and said control means configured to:

- i) energise said conduit heating means (12) depending on at least said estimate of the rate of condensation, to a level appropriate to substantially vaporise any liquid condensate present in said gases transportation pathway means (11); and
- ii) energise said conduit heating means (12) depending on at least said estimate of the rate of condensation, to a level appropriate to minimise any condensation of the vapour from said gases in said gases transportation pathway means (11).

8. A humidification apparatus as claimed in claim 7 said steps (i) and (ii) are repeated continually at regular intervals.

9. A humidification apparatus as claimed in claim 7 wherein said steps (i) and (ii) are alternated at regular intervals.

10. A humidification apparatus as claimed in claim 2 wherein said gases transportation pathway means (11) having a patient end (5), distal to said end connected to said outlet (10) of said humidification chamber means (1) said humidity sensing means comprising a first temperature sensor (7) in substantial proximity to said outlet (10) of said humidification chamber means (1) and an absolute humidity sensor (8) in substantial proximity to said patient end (5) of said gases transportation pathway means (11).

11. A humidification apparatus as claimed in claim 10 further comprising conduit heating means (12) adapted to heat said gases flow in said gases transportation pathway means (11) and/or said gases transportation pathway means (11), and said control means configured to energise said conduit heating means (12) depending on at least said estimate of the rate of condensation, at a level appropriate to minimise any condensation of the vapour from

said gases in said gases transportation pathway means (11) as well as convey said gases flow to said patient or other person in need of such gases substantially at a predetermined level of absolute humidity.

12. A humidification apparatus as claimed in claim 1 wherein said humidity sensing means (7, 8) comprising at least a temperature sensor and at least one relative humidity sensor providing an indication of the temperature and relative humidity at least at one point in the flow path of said gases flow through said apparatus.

13. A humidification apparatus as claimed in any one of the preceding claims wherein further comprising flow sensing means adapted to provide an indication of the rate of flow of said gases flown through said apparatus.

14. A humidification apparatus as claimed in claim 13 wherein said flow sensing means comprising a heated element adapted to maintain a substantially constant temperature and being provided in the flow path of said gases through said apparatus, the heat loss therefrom providing an indication of the rate of flow of said gases.

15. A humidification apparatus as claimed in any one of the preceding claims wherein said humidity sensing means further comprising disposable cover means for providing a substantial barrier to microorganisms between said flow of gases and said temperature sensor.

16. A humidification apparatus as claimed in any one of claims 1 to 14 wherein said humidity sensing means (7, 8) further comprising porous disposable cover means for providing porous material as a substantial barrier to microorganisms between said flow of gases and said humidity sensing means (7, 8).

17. A humidification apparatus for humidifying a gases flow to be supplied to a patient or other person in need of such gases comprising:

humidification chamber means (1) and having an inlet (4) and an outlet (10) to allow said gases flow to pass through said humidification chamber means (1),

***characterised in that***

chamber heating means provided adjacent said humidification chamber means (1) including wet heating means (9) adapted to vaporise liquid water (21) in said humidification chamber means (1) in order to provide water vapour to said gases flow passing through said humidifi-

- cation chamber means (1) and dry heating means (20) adapted to directly heat said gases flow passing through said humidification chamber means (1),  
 gases transportation pathway means (11) connected to said outlet (10) of said humidification chamber means (1) to convey said gases flow to said patient or other person in need of such gases, and  
 control means configured to energise said wet heating means (9) and said dry heating means (20) to achieve a desired level of absolute humidity.
18. A humidification apparatus as claimed in claim 17 wherein said apparatus further comprising humidity sensing means (7, 8) for providing an indication of the absolute humidity of said gases flow at least one point in the flow path through said apparatus of said gases flow.
19. A humidification apparatus as claimed in claims 17 or 18 wherein said chamber heating means comprises a metal spiral element (20).
20. A humidification apparatus as claimed in claims 17 or 18 wherein said chamber heating means comprises a heated porous ceramic member (22) adapted to be in contact with said liquid water and said gases flow.
21. A humidification apparatus as claimed in claims 17 or 18 wherein heating means comprises a heated semipermeable membrane (24) adapted to be in contact with said liquid water and said gases flow.
22. A humidification apparatus as claimed in any one of claims 17 to 21 wherein said humidification chamber means further having a humidification bypass means, for allowing a portion of said gases to flow to pass from said inlet (4) of said humidification chamber means (1) to said outlet (10) of said humidification chamber means (1) substantially without humidification.
23. A humidification apparatus as claimed in claim 22 wherein said humidification bypass means including a bypass conduit means (27) at least partially passing through said quantity of water (28) for conveying a portion of said gases flow from said inlet (4) of said humidification chamber means (1) to said outlet (10) of said humidification chamber means (1), and a valve means (26) provided in said bypass conduit means (27) to thereby control the flow rate of the portion of said gases flow in said bypass conduit means (27), the temperature of gases flowing through said bypass conduit means (27) being affected by the temperature of said quantity of water (28).
24. A humidification apparatus as claimed in claim 17 to 21 wherein said humidification chamber means (1) further having a bypass conduit means (33) for conveying a portion of said gases flow from said inlet (4) of said humidification chamber means (1) to said outlet (10) of said humidification chamber means (1) including a bypass heating means (58) adapted to heat the portion of said gases flow in said bypass conduit means (33) and/or said bypass conduit means (33), and a valve means (30) provided in said bypass conduit means (33) to thereby control the flow rate of the portion of said gases flow in said bypass conduit means (33).
25. A humidification apparatus as claimed in claims 23 or 24 wherein the restriction provided by said valve means (26, 30) on the flow rate of the portion of said gases flow in said bypass conduit means (27, 33) is in use permanently set.
26. A humidification apparatus as claimed in claims 23 or 24 wherein the restriction provided by said valve means (26, 30) on the flow rate of the portion of said gases flow in said bypass conduit means (27, 33) is in use manually adjustable.
27. A humidification apparatus as claimed in claims 23 or 24 further comprising flow sensing means providing an indication of the instantaneous flow rate wherein said control means configured to control the restriction provided by said valve means (26, 30) on the flow rate of the portion of said gases flow in said bypass conduit means (27, 33) based on said indication of instantaneous flow rate of said gases flow through said humidification chamber means (1), in order that the gases flow exiting from said humidification chamber means (1) is of substantially constant humidity.
28. A humidification apparatus as claimed in any one of claims 23 to 27 wherein said valve means comprising an electromechanical actuator connected to a valve member wherein the energisation of said electromechanical actuator varies the position of said valve member thereby varying the restriction provided by said valve means on the flow rate of the portion of said gases flow in said bypass conduit means.
29. A humidification apparatus as claimed in any one of claims 23 to 27 wherein said valve means comprising either a valve member connected to an elastic member or an elastic valve member wherein said valve being positioned in said gases flow at said inlet to humidification chamber means and the position of said valve member or said elastic valve

member thereby determines the portion of said gases flow in said bypass conduit means.

30. A humidification apparatus as claimed in claim 29 wherein the position of said valve member or said elastic valve member providing an indication of the rate of flow of said gases flow at said inlet to humidification chamber means.

31. A humidification apparatus as claimed in claim 17 further comprising gases heating means (37) adjacent to said inlet (35) of said humidification chamber means (1), for heating of said flow of gases prior to being humidified.

32. A humidification apparatus as claimed in any one of claims 17 to 21 wherein said apparatus further comprising gases heating means (38) adjacent to said outlet (39) of said humidification chamber means (1), for heating of said flow of gases subsequent to being humidified.

33. A humidification apparatus as claimed in any one of claims 17 to 32 wherein said gases transportation pathway means (41) includes insulation means (42) adapted to minimise the rate of heat energy lost by said gases flow in said gases transportation pathway means (41), said control means adapted to energise said chamber heating means (138) to minimise the condensation of the vapour from said gases in said gases transportation pathway means (41) while providing predetermined levels of absolute humidity.

34. A humidification apparatus for humidifying a gases flow to be supplied to a patient or other person in need of such gases comprising:

humidification chamber means (52) and having an inlet (51) and an outlet to allow said gases flow to pass through said humidification chamber means (52),

chamber heating means (54) provided adjacent said humidification chamber means (52) and adapted to vaporise liquid water (53) in said humidification chamber means (52) in order to provide water vapour to said gases flow passing through said humidification chamber means (52),

gases transportation pathway means (56) connected to said outlet of said humidification chamber means (52) to convey said gases flow to said patient or other person in need of such gases, and

*characterised in that*

regulated conduit heating means (48) are associated with said gases transportation means and

configured to regulate the temperature profile of said gases flow along said gases transportation pathway means (56) and/or of said gases transportation pathway means (56), to substantially coincide with a predetermined profile.

35. A humidification apparatus as claimed in claim 34 wherein said regulated conduit heating means (48) comprising at least one section of positive temperature coefficient material wherein the localised electrical resistance of each said section is positively related to the localised temperature.

36. A humidification apparatus as claimed in claim 34 wherein said regulated conduit heating means (48) comprising at least one section of negative temperature coefficient material wherein the localised electrical resistance of said section is negatively related to the localised temperature.

37. A humidification apparatus as claimed in claim 34 wherein said regulated conduit heating means (48) comprising a plurality of sections of positive temperature coefficient material wherein the localised electrical resistance of each said section is positively related to the localised temperature section and at least two electrical conductors (46, 47) running along said gases transportation pathway means (56), each said conductor (46, 47) being electrically connected to a separate portion of each said section and each said section being electrically isolated (50) from all other sections except for the connection through each said conductor.

38. A humidification apparatus as claimed in claims 34 to 37 wherein said gases transportation pathway means further comprising an inspiratory conduit means (11) in fluid communication with said outlet (10) of said humidification chamber (1), a connector means (13) in fluid communication with said inspiratory conduit means, a flexible tube extension means in fluid communication with said connector means and patient interface means in fluid communication with said flexible tube extension means adapted to convey said gases flow to said patient.

39. A humidification apparatus as claimed in claim 38 wherein said flexible tube extension means comprising flexible tube extension heating means including at least one section of positive temperature coefficient material wherein the localised electrical resistance of said material is positively related to the localised temperature.

40. A humidification apparatus as claimed in claims 38 or 39 wherein said patient interface means comprising patient interface heating means including at least one section of positive temperature coefficient

material wherein the localised electrical resistance of each said section of said material is positively related to the localised temperature.

41. A humidification apparatus as claimed in any one of claims 34 to 40 further comprising humidity sensing means for providing an indication of the absolute humidity of said gases flow at said outlet (55) of said humidity chamber means (52).
42. A humidification apparatus as claimed in any one of claims 34 to 41 wherein further comprising temperature sensing means for providing an indication of the temperature of said gases flow at said outlet (55) of said humidity chamber means (52).
43. A humidification apparatus as claimed in claim 34 wherein said gases transportation pathway means (56) comprising a double walled inspiratory conduit and said regulated conduit heating means comprising the provision of warm fluid circulated between the inner wall and outer wall of said double walled inspiratory conduit.
44. A humidification apparatus as claimed in any one of the claims 34 to 43 wherein said predetermined profile relates to a substantially constant temperature along the length of said gases transportation pathway means.
45. A humidification apparatus for humidifying a gases flow to be supplied to a patient or other person in need of such gases comprising:

humidification chamber means (60) and having an inlet (63) and an outlet (64) to allow said gases flow to pass through said humidification chamber means (60), chamber heating means (62) provided adjacent said humidification chamber means (60) and adapted to vaporise liquid water in said humidification chamber means (60) in order to provide water vapour to said gases flow passing through said humidification chamber means (60), and

***characterised in that***

chamber manifold means (59) including mounting means (72, 73) in use housing at least one sensing means in proximity to said outlet of said humidification chamber means, said chamber manifold means configured to connect: said inlet (63) of said humidification chamber means (60) to a supply conduit means (65) said supply conduit means (65) in use in fluid communication with a gases supply means for supplying said gases flow at a desired pressure,

and/or said outlet (64) of said humidification chamber means (60) to a gases transportation pathway means (66) for conveying said gases flow to said patient or other person in need of such gases.

46. A humidification apparatus as claimed in claim 45 wherein said chamber manifold means (59) further including chamber manifold heating means adapted to heat said gases flow through said chamber manifold means (59) and/or said chamber manifold means (59).
47. A humidification apparatus as claimed in claims 45 or 46 wherein said chamber manifold means (59) is attachable to and removable from said humidification chamber means (60).
48. A humidification apparatus for humidifying a gases flow to be supplied to a patient or person in need of such gases as herein described with reference to and as illustrated by the accompanying drawings.

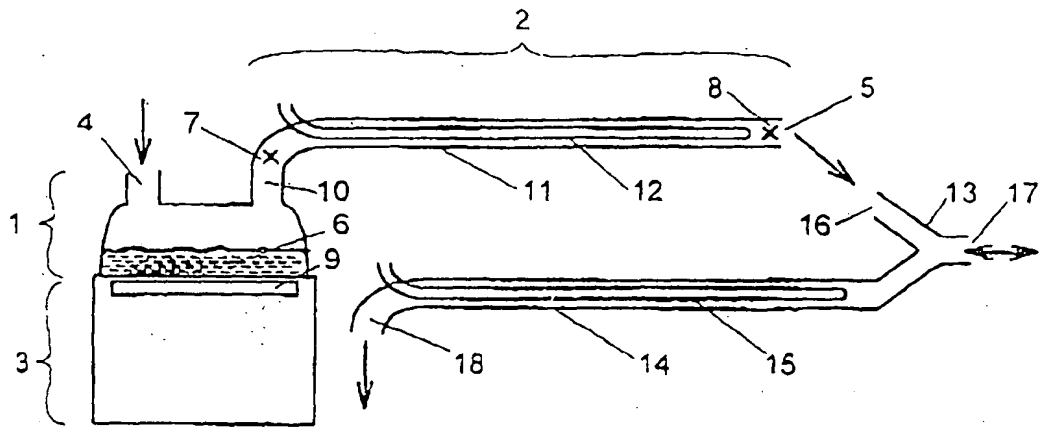


Figure 1

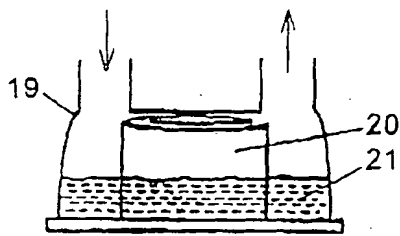


Figure 2

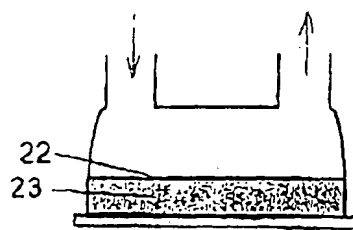


Figure 3

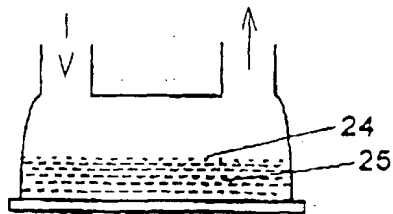


Figure 4

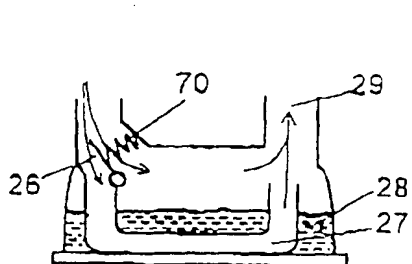


Figure 5

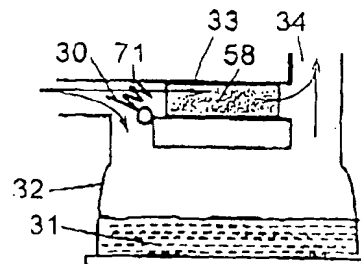


Figure 6

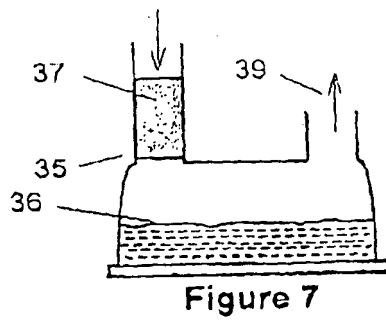


Figure 7

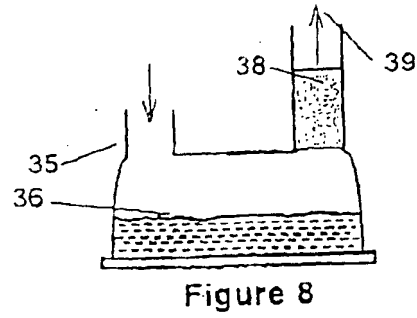


Figure 8

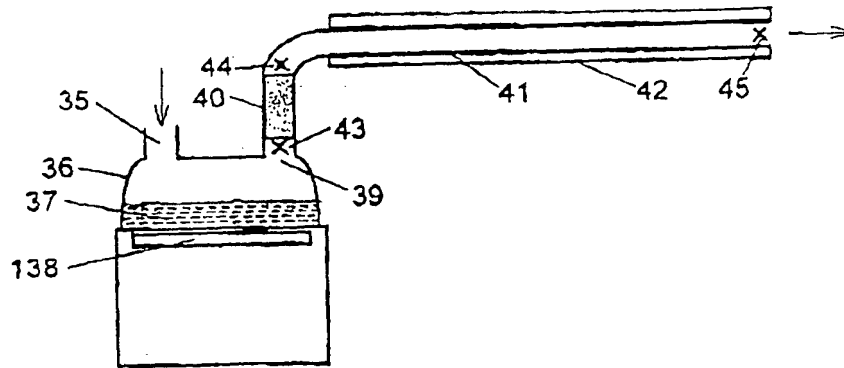


Figure 9

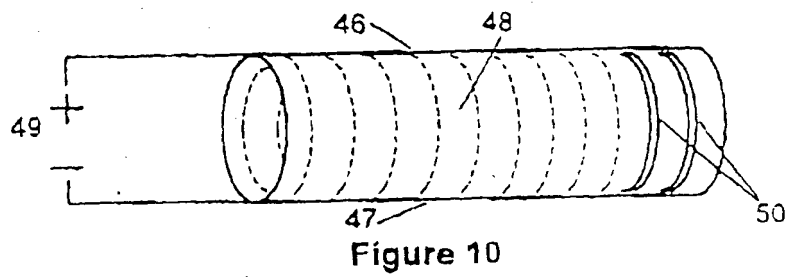


Figure 10

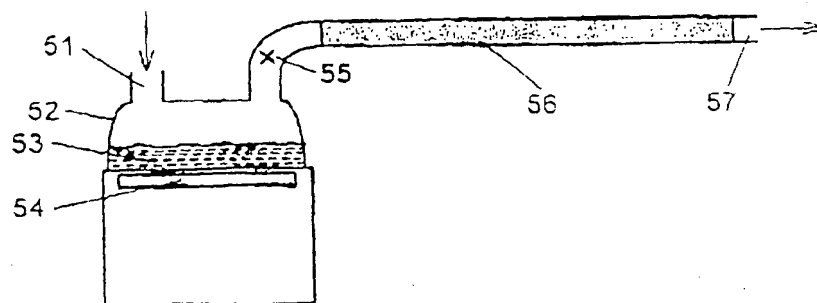


Figure 11

BEST AVAILABLE COPY

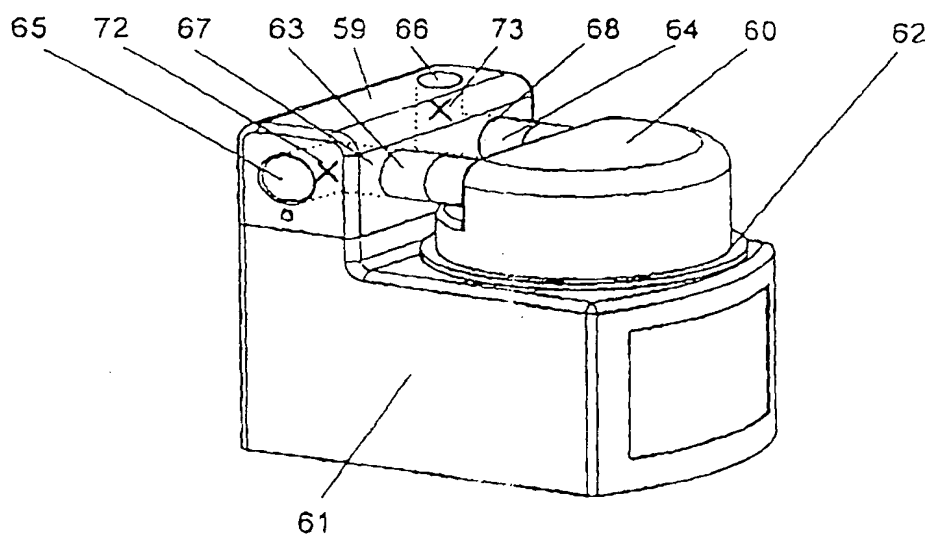


Figure 12

BEST AVAILABLE COPY

**THIS PAGE BLANK (USPTO)**



(19)



Europäisches Patentamt  
European Patent Office  
Office européen des brevets



(11)

**EP 1 138 341 A3**

(12)

**EUROPEAN PATENT APPLICATION**

(88) Date of publication A3:  
13.08.2003 Bulletin 2003/33

(51) Int Cl.7: **A61M 16/10, A61M 16/16**

(43) Date of publication A2:  
04.10.2001 Bulletin 2001/40

(21) Application number: **01106827.7**

(22) Date of filing: **19.03.2001**

(84) Designated Contracting States:  
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE TR**  
Designated Extension States:  
**AL LT LV MK RO SI**

(72) Inventors:  
• **Seakins, Paul John**  
**Pakuranga, Auckland (NZ)**  
• **Smith, Malcolm David**  
**Royal Oak, Auckland (NZ)**  
• **Thudor, Mohammad**  
**Parnell, Auckland (NZ)**

(30) Priority: **21.03.2000 NZ 50349500**

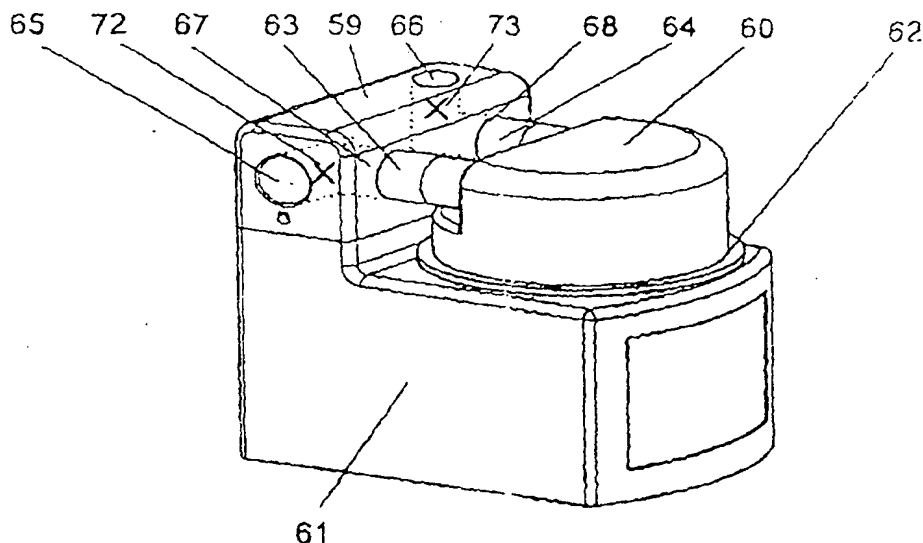
(71) Applicant: **FISHER & PAYKEL LIMITED**  
**Auckland (NZ)**

(74) Representative: **Brown, John David**  
**FORRESTER & BOEHMERT**  
**Pettenkoferstrasse 20-22**  
**80336 München (DE)**

**(54) Humidification apparatus**

(57) A humidifier and humidity sensor is disclosed for use with a breathing assistance apparatus. The humidity sensor preferably includes means to sense absolute humidity, relative humidity and/or temperature at both the patient end and humidifier end. The humidifier

may also include provision to both control independently the humidity and temperature of the gases. Further, a chamber manifold is disclosed to facilitate easy connection of the humidifier to various outlets, inlets and sensors. A heated conduit is described which provides a more effective temperature profile along its length.



**Figure 12**

**BEST AVAILABLE COPY**

**EP 1 138 341 A3**



European Patent  
Office

# PARTIAL EUROPEAN SEARCH REPORT

Application Number

which under Rule 45 of the European Patent Convention EP 01 10 6827 shall be considered, for the purposes of subsequent proceedings, as the European search report

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 01, 30 January 1998 (1998-01-30) & JP 09 234247 A (NIKKISO Y S I KK), 9 September 1997 (1997-09-09) *figure* * abstract *	1,12	A61M16/10 A61M16/16
Y		2-11, 13-16, 18,34-44	
X	--- PATENT ABSTRACTS OF JAPAN vol. 018, no. 134 (C-1176), 4 March 1994 (1994-03-04) & JP 05 317428 A (MASAHIDE OOTSUKA;OTHERS: 01), 3 December 1993 (1993-12-03) *figure* * abstract *	1,12	
Y		2-11, 13-16, 18,34-44	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			A61M
<b>INCOMPLETE SEARCH</b> The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC to such an extent that a meaningful search into the state of the art cannot be carried out, or can only be carried out partially, for these claims. Claims searched completely : 1-47 Claims searched incompletely :  Claims not searched : 48 Reason for the limitation of the search: Claim 48 is defined based on the description and drawings, contrary to the requirements of Rule 29(6). Lack of clarity (Art. 84 EPC) arises.			
Place of search		Date of completion of the search	Examiner
MUNICH		23 June 2003	Skorovs, P
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

EPO FORM 1503 03.82 (P04C07)



European Patent  
Office

## PARTIAL EUROPEAN SEARCH REPORT

Application Number  
EP 01 10 6827

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	W0 98 26826 A (COOK WILLIAM A AUSTRALIA) 25 June 1998 (1998-06-25)	17,31,32	
Y	* page 2, line 21 - page 8, line 2 * * figures 1,2 *	18-22,33	
X	US 5 392 770 A (CLAWSON BURRELL E ET AL) 28 February 1995 (1995-02-28) * column 6, line 60 - column 7, line 42 * * figures 1,3,6 * * figure 8 *	45-47	
Y	US 5 346 128 A (WACKER PAUL C) 13 September 1994 (1994-09-13) *abstract* * figure 1 *	2-16	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
Y	US 4 060 576 A (GRANT GRAHAM CAMERON) 29 November 1977 (1977-11-29) * column 2, line 3 - line 13; figure 1 *	6-9, 11-14	
Y	EP 0 885 623 A (FISHER & PAYKEL) 23 December 1998 (1998-12-23) * abstract; figure 3 *	13,14	
Y	EP 0 985 422 A (SIEMENS ELEMA AB) 15 March 2000 (2000-03-15) * abstract *	15,16	
Y	US 5 062 145 A (OREC ILIJA ET AL) 29 October 1991 (1991-10-29) * column 1, line 16 - column 7, line 26 *	19,21	
Y	US 3 695 267 A (HIRTZ HANNES JOACHIM ET AL) 3 October 1972 (1972-10-03) * column 3, line 57 - line 62 *	20	
	--- -/--		

EPO FORM 1503 03.02 (P04C10)



European Patent  
Office

## PARTIAL EUROPEAN SEARCH REPORT

Application Number  
EP 01 10 6827

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
Y	US 4 722 334 A (HEDMAN JONATHAN W ET AL) 2 February 1988 (1988-02-02) * column 7, line 37 - line 40 *	22	
A	* figure 1 *	23-30	
Y	EP 0 672 430 A (FISHER & PAYKEL) 20 September 1995 (1995-09-20) * column 3, line 34 - column 10, line 51 *	33	
Y	EP 0 258 928 A (PONNET GILMAN EN ANTHONY) 9 March 1988 (1988-03-09) * column 1, line 33 - column 4, line 17 * * figure 1 *	34,37, 38,41,44	
Y	GB 1 167 551 A (TEXAS INSTRUMENTS INC.) 15 October 1969 (1969-10-15) * page 1, line 11 - page 4, line 91 *	35,39,40	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
Y	DE 40 34 611 A (STIEBEL ELTRON GMBH & CO KG) 7 May 1992 (1992-05-07) * column 1, line 1 - column 2, line 45 *	36	
Y	US 5 529 060 A (DANIELL MICHAEL G ET AL) 25 June 1996 (1996-06-25) * column 1, line 52 - column 6, line 5 *	42	
Y	US 4 013 122 A (LONG RICHARD WILLIAM) 22 March 1977 (1977-03-22) * column 1, line 25 - column 3, line 5 * * figure 3 *	43	
A	SU 379 270 A (DANILENKO M V ET AL) 20 April 1973 (1973-04-20) * the whole document *	22-30	
	---		
	-/--		

EPO FORM 1503 03.82 (P04C10)

European Patent  
Office

## PARTIAL EUROPEAN SEARCH REPORT

Application Number  
EP 01 10 6827

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	US 4 574 188 A (MIDGLEY JOHN A ET AL) 4 March 1986 (1986-03-04) * the whole document * -----	35,36, 39,40	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)

EPO FORM 1503 03.82 (P04C10)

BEST AVAILABLE COPY



European Patent  
Office

Application Number

EP 01 10 6827

### CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

### LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- ☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:



European Patent  
Office

**LACK OF UNITY OF INVENTION  
SHEET B**

Application Number

EP 01 10 6827

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

**1. Claims: 1-16**

Apparatus for humidifying a gases flow to be supplied to a patient or other person in need of such gases comprising humidification chamber means and having an inlet and an outlet to allow said gases flow to pass through said humidification chamber means, chamber heating means provided adjacent said humidification chamber means and adapted to vaporise liquid water in said humidification chamber means in order to provide water vapour to said gases flow passing through said humidification chamber means, a gases transportation pathway means connected to said outlet of said humidification chamber means to convey said gases flow to said patient, whereby humidity sensing means configured to provide an indication of the absolute humidity of said gases flow at least at one point in the flow path through said apparatus of said gases flow.

**2. Claims: 17-33**

A humidification apparatus for humidifying a gases flow to be supplied to a patient or other person in need of such gases comprising humidification chamber means and having an inlet and an outlet to allow said gases flow to pass through said humidification chamber means, whereby said chamber heating means provided adjacent said humidification chamber means including wet heating means adapted to vaporise liquid water in said humidification chamber means in order to provide water vapour to said gases flow passing through said humidification chamber means and dry heating means adapted to directly heat said gases flow passing through said humidification chamber means, gases transportation pathway means connected to said outlet of said humidification chamber means to convey said gases flow to said patient or other person in need of such gases, and control means configured to energise said wet heating means and said dry heating means to achieve a desired level of absolute humidity.

**3. Claims: 34-44**

A humidification apparatus for humidifying a gases flow to be supplied to a patient or other person in need of such gases comprising humidification chamber means and having an inlet and an outlet to allow said gases flow to pass through said humidification chamber means, chamber heating means provided adjacent said humidification chamber means and adapted to vaporise liquid water in said humidification chamber means in order to provide water vapour to said gases

European Patent  
Office**LACK OF UNITY OF INVENTION  
SHEET B**

Application Number

EP 01 10 6827

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

flow passing through said humidification chamber means, gases transportation pathway means connected to said outlet of said humidification chamber means to convey said gases flow to said patient or other person in need of such gases, and whereby regulated conduit heating means are associated with said gases transportation means and configured to regulate the temperature profile of said gases flow along said gases transportation pathway means and/or of said gases transportation pathway means, to substantially coincide with a predetermined profile.

**4. Claims: 45-47**

A humidification apparatus for humidifying a gases flow to be supplied to a patient or other person in need of such gases comprising humidification chamber means and having an inlet and an outlet to allow said gases flow to pass through said humidification chamber means, chamber heating means provided adjacent said humidification chamber means and adapted to vaporise liquid water in said humidification chamber means in order to provide water vapour to said gases flow passing through said humidification chamber means, and whereby chamber manifold means including mounting means in use housing at least one sensing means in proximity to said outlet of said humidification chamber means, said chamber manifold means configured to connect said inlet of said humidification chamber means to a supply conduit means said supply conduit means in use in fluid communication with a gases supply means for supplying said gases flow at a desired pressure, and/or said outlet of said humidification chamber means to a gases transportation pathway means for conveying said gases flow to said patient or other person in need of such gases.



ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.

EP 01 10 6827

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

23-06-2003

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
JP 09234247	A	09-09-1997	NONE	
JP 05317428	A	03-12-1993	JP 2654887 B2	17-09-1997
WO 9826826	A	25-06-1998	AU 4833197 A	25-06-1998
			AU 5233198 A	15-07-1998
			WO 9826826 A1	25-06-1998
			US 6010118 A	04-01-2000
US 5392770	A	28-02-1995	NONE	
US 5346128	A	13-09-1994	AU 6861594 A	02-02-1995
			CA 2128566 A1	23-01-1995
US 4060576	A	29-11-1977	US 4051205 A	27-09-1977
			AU 1018376 A	14-07-1977
			AU 473258 B2	17-06-1976
			AU 5942273 A	20-02-1975
			CA 1010359 A1	17-05-1977
			DE 2345677 A1	28-03-1974
			ES 418736 A1	01-06-1976
			FR 2198758 A1	05-04-1974
			GB 1448474 A	08-09-1976
			GB 1448473 A	08-09-1976
			IT 998583 B	20-02-1976
			JP 952478 C	25-05-1979
			JP 50012896 A	10-02-1975
			JP 53026080 B	31-07-1978
			NL 7312339 A ,B,	15-03-1974
			SE 407151 B	19-03-1979
			ZA 7305803 A	28-08-1974
EP 0885623	A	23-12-1998	AU 729862 B2	08-02-2001
			AU 7195098 A	24-12-1998
			CA 2240812 A1	17-12-1998
			CN 1210020 A	10-03-1999
			EP 0885623 A2	23-12-1998
			JP 11057009 A	02-03-1999
			JP 2003000716 A	07-01-2003
			JP 2003010334 A	14-01-2003
			JP 2002345965 A	03-12-2002
			US 2002139367 A1	03-10-2002
			US 6349722 B1	26-02-2002
			US 2002129815 A1	19-09-2002
EP 0985422	A	15-03-2000	EP 0985422 A2	15-03-2000

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

# ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 01 10 6827

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

23-06-2003

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0985422	A		JP 2000084080 A	28-03-2000
			US 6397846 B1	04-06-2002
US 5062145	A	29-10-1991	NZ 226392 A	28-10-1992
			NZ 226784 A	28-10-1992
			AU 614875 B2	12-09-1991
			AU 4175189 A	05-04-1990
			DE 3932766 A1	05-04-1990
			FR 2636845 A1	30-03-1990
			GB 2223694 A ,B	18-04-1990
			GB 2252515 A ,B	12-08-1992
			JP 2193680 A	31-07-1990
US 3695267	A	03-10-1972	DE 1933350 A1	21-01-1971
			DE 2020435 A1	11-11-1971
			AT 318797 B	11-11-1974
			AT 312154 B	27-12-1973
			BE 752749 A1	01-12-1970
			CA 923005 A1	20-03-1973
			CH 545113 A	15-12-1973
			CH 507715 A	31-05-1971
			DK 127228 B	08-10-1973
			ES 381285 A1	01-04-1973
			FR 2056428 A5	14-05-1971
			GB 1310949 A	21-03-1973
			LU 61211 A1	26-08-1970
			NL 7009418 A	05-01-1971
			NL 7202911 A	12-06-1973
			NO 127435 B	25-06-1973
US 4722334	A	02-02-1988	AU 4960585 A	10-02-1987
			AU 5757390 A	11-10-1990
			CA 1249190 A1	24-01-1989
			EP 0228374 A1	15-07-1987
			NZ 213826 A	28-07-1988
			WO 8700423 A1	29-01-1987
			US 4953546 A	04-09-1990
			US 4955372 A	11-09-1990
EP 0672430	A	20-09-1995	AU 1486195 A	21-09-1995
			EP 0672430 A2	20-09-1995
			JP 8109984 A	30-04-1996
			US 5640951 A	24-06-1997
EP 0258928	A	09-03-1988	BE 905330 A2	16-12-1986
			DE 3774510 D1	19-12-1991

EPO FORM P459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

# ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 01 10 6827

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

23-06-2003

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0258928 A		EP 0258928 A1	09-03-1988
		ES 2027282 T3	01-06-1992
GB 1167551 A	15-10-1969	CA 949636 A2	18-06-1974
		DE 1565888 A1	16-04-1970
		FR 1510940 A	26-01-1968
		GB 1168770 A	29-10-1969
		NL 6616002 A	02-06-1967
DE 4034611 A	07-05-1992	DE 4034611 A1	07-05-1992
US 5529060 A	25-06-1996	NONE	
US 4013122 A	22-03-1977	NONE	
SU 379270 A	20-04-1973	SU 379270 A1	20-04-1973
US 4574188 A	04-03-1986	AT 77527 T	15-07-1992
		CA 1207366 A1	08-07-1986
		DE 3382581 D1	23-07-1992
		DE 3382581 T2	02-03-1995
		EP 0092406 A2	26-10-1983
		GB 2118810 A ,B	02-11-1983
		GB 2163330 A ,B	19-02-1986
		HK 39388 A	03-06-1988
		HK 39588 A	03-06-1988
		IN 159153 A1	04-04-1987
		JP 1828987 C	15-03-1994
		JP 5026316 B	15-04-1993
		JP 59063690 A	11-04-1984
		KR 9104275 B1	25-06-1991
		US 4659913 A	21-04-1987
		US 4582983 A	15-04-1986
		US 4791276 A	13-12-1988

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**THIS PAGE BLANK (USPTO)**